AD-A060 982 ITT ELECTRO-OPTICAL PRODUCTS DIV ROANOKE VA F/G 9/1

WIDE RIM MICROCHANNEL PLATES(U)

NOV 77 R LAYMAN, C SICORA DAAG53-76-C-0197

UNCLASSIFIED NL

1 OF 1

ADA

060982

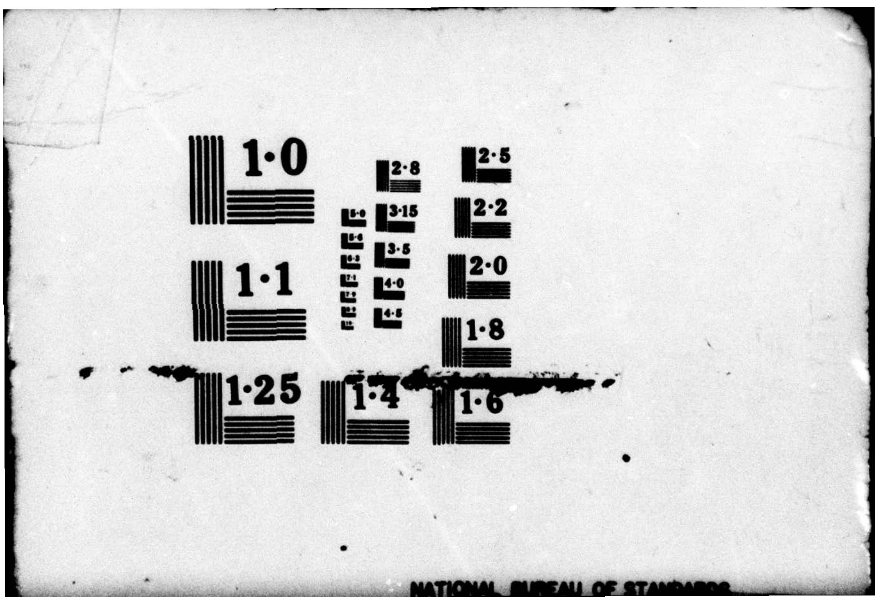
END

DATE

FILMED

1 79

DDC


1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5
2·8
3·15
3·5
4·0
4·5
NATIONAL BUREAU OF STANDARDS

FINAL REPORT

WIDE RIM MICROCHANNEL PLATES

29 JUNE 1976 TO 30 JUNE 1977
CONTRACT NUMBER: DAAG53-76-C-0197

U. S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
PROCUREMENT AND PRODUCTION OFFICE
FORT BELVOIR, VIRGINIA 22060

ITT Electro-Optical Products Division
7635 Plantation Road, Roanoke, Va. 24019

"This project has been accomplished as part of the US Army (Manufacturing and Technology) Program, which has its objective the timely establishment of manufacturing processes, techniques or equipment to insure the efficient production of current or future defense programs".

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

(9) Final rept.

4. TITLE (and Subtitle)

(6) WIDE RIM MICROCHANNEL PLATES

5. TYPE OF REPORT & PERIOD COVERED

29 Jun 76 - 30 Jun 77

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) Rodney Layman, Charles Sicora

8. CONTRACT OR GRANT NUMBER(s)

(15) DAAG53-76-C-0197

9. PERFORMING ORGANIZATION NAME AND ADDRESS

ITT ELECTRO-OPTICAL PRODUCTS DIVISION
P. O. BOX 7065
ROANOKE, VIRGINIA 24019

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

U. S. ARMY MOBILITY EQUIPMENT
RESEARCH & DEVELOPMENT COMMAND
PROCUREMENT AND PRODUCTION OFFICE
FORT BELVOIR, VIRGINIA 22060

12. REPORT DATE

(11) Nove[illegible] [illegible]977

13. NUMBER OF PAGES

23

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

SAME AS ABOVE

(12) 32p.

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

"Approved for public release, distribution unlimited."

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

MICROCHANNEL PLATES, WIDE RIM

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Wide rim 18 mm microchannel plates were successfully manufactured during this contract. The necessary modifications to fixturing and equipment to accomplish the program objectives are detailed in this report. Adjustments to hydrogen firing and vacuum baking schedules were made to achieve optimized MCP characteristics. Detailed test results of all wide rim MCPs processed are included in Tables I, II and III.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

78 11 06 045

189 750

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(1)

WIDE RIM MICROCHANNEL PLATES

FINAL REPORT

(29 JUNE 1976 TO 30 JUNE 1977)

NOVEMBER 1977

PREPARED FOR:

U. S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
PROCUREMENT AND PRODUCTION OFFICE
FORT BELVOIR, VIRGINIA 22060

CONTRACT NUMBER: DAAG53-76-C-0197

PREPARED BY:

ITT ELECTRO-OPTICAL PRODUCTS DIVISION
7635 PLANTATION ROAD
ROANOKE, VIRGINIA 24019

"Approved for public release, distribution unlimited"

APPROVED BY:	APPROVED BY:
A. R. Asam, Manager MCP, Fiber Optic Waveguide and Cabling Operations	M. F. Toohig, Vice President & Director of Engineering

ABSTRACT

Wide rim 18 mm microchannel plates were successfully manufactured during this contract. The necessary modifications to fixturing and equipment to accomplish the program objectives are detailed in this report. Adjustments to hydrogen firing and vacuum baking schedules were made to achieve optimized MCP characteristics. Detailed test results of all wide rim MCPs processed are included in Tables I, II and III.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

The objective of this program is to develop a wide rim MCP with special physical and electronic properties required for use in an MCP-in-the-wall (MIW) structure. The purpose of the effort is to develop manufacturing techniques for MCPs with an extra wide solid border and to develop and establish initial performance characteristics compatible with MIW applications.

2.0 TECHNICAL DISCUSSION

Standard microchannel plates of the 18, 25 or 40 mm format are produced with a solid border ranging in width from .060" to .100". In order to achieve this width, glass tubing with a suitable wall thickness is employed which is either used as the packing tube during boule assembly or as a precision bore sleeve over the precision ground and polished boule. To match the expansion coefficient of the 8161 matrix glass, high lead content glass tubing must be employed. The 8161 glass tubing, if available in the right size, is the ideal choice. An alternate glass which is lower in lead content is 0120. Unfortunately, both glasses were not available to EOPD in the size required to form a solid border having a width of .170 inches. However, a technique was developed whereby the packing tube was inserted into a second glass tube and a vacuum jacket prior to performing the boule press operation. The glass tubing which was finally incorporated, was used for reasons of compatability and availability. This technique was useful in providing the required border width as shown in Figure 1.1. The active area shown is slightly larger than requested in order to guarantee an undistorted quality area after the final boule press.

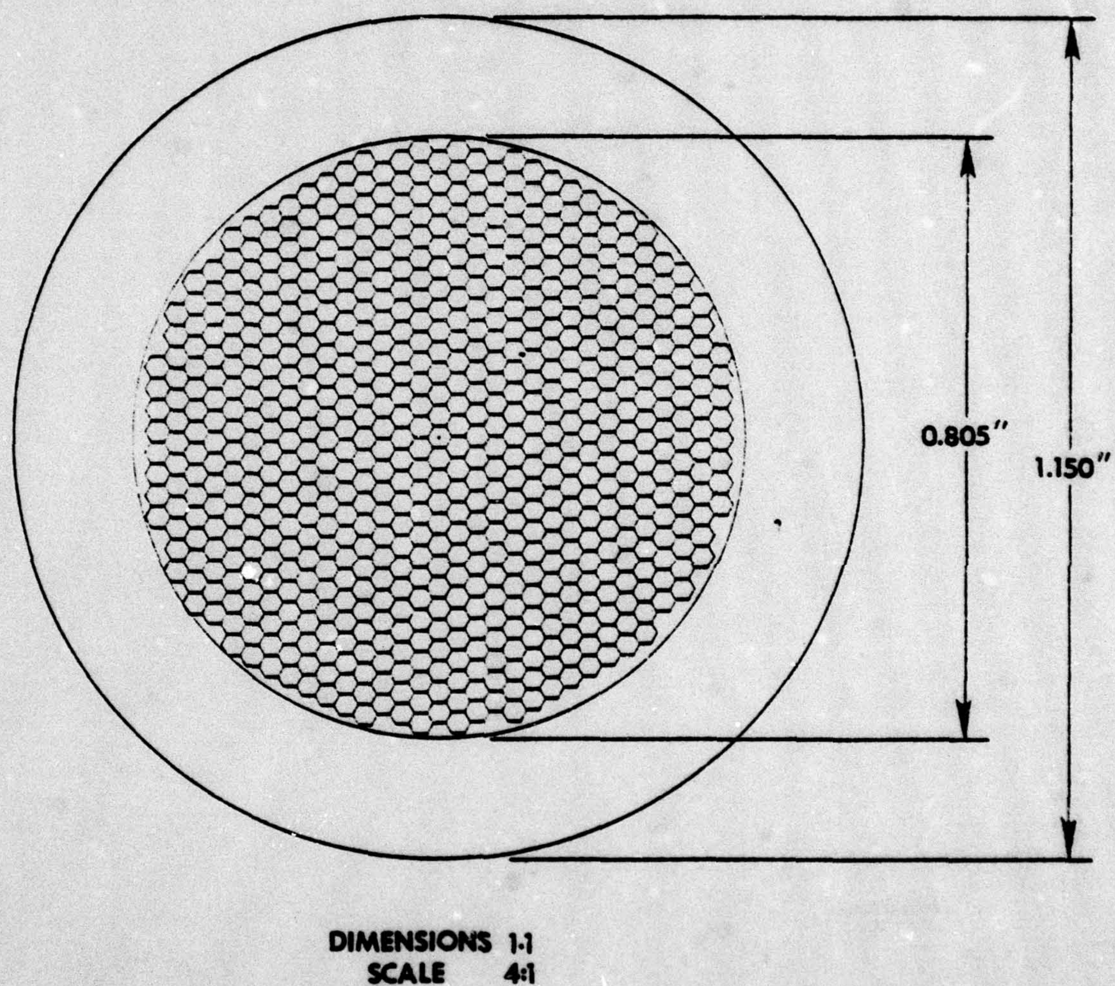


Figure 1.1. Schematic of Wide Rim MCP.

2.1 Wide Rim MCP Fabrication

2.1.1 Single Draw

A single draw was made with 1.050" core glass and a piece of 8161 of 1.183" inside diameter and 1.618" outside diameter. The fibers were eighteen inches long and of .0254 ± .0002" diameter. During the draw the fiber size was controlled manually and checked by hand with a micrometer. All fibers were then remeasured after the draw and only those measuring .0252" to .0256" were used to assemble the hexagonal multistructure.

2.1.2 Cleaning Singles

Single fibers selected for use in multiples were separated into groups of about fifty, which then in turn were put in cleaning tubes. The tubes were then placed into a large pan of chemicals and agitated. Each tube had a slot in the bottom so the chemicals could flow freely around and across the total length of the fibers. Once clean, the fibers were hot air dried.

2.1.3 Packing the Multiple

The single fibers were packed into a hex shaped mold with

thirty fibers to a flat. All fibers were visually inspected for inclusions and for other contaminants before packing. After packing the multiple, it was transferred to an adjustable mold. This mold gives uniform support to all fibers. The multiple arrangement was then put into a tacking furnace in which the single fibers were tacked together forming the hex shape of the final multiple fiber.

2.1.4 Multiple Draw

The tacked multiple was set up in a draw tower in a fashion similar to the single draw and then drawn down to fibers of .0247" and .0248" diameter and a length of twelve inches. The single fiber size resulted in a plate with an 11.9 micron center-to-center spacing. Again fiber size was controlled manually. The twelve inch fibers were then cut in half and measured individually end for end. Fibers measuring in the range of .0247" to .0248" were selected for use in the final boule.

2.1.5 Boule Packing, First and Second Press

The multiple fibers were cleaned in six inch cleaning tubes following the same procedure used for the cleaning of singles. These fibers were packed in a .930" I.D. packing tube The tube containing the fibers was then placed into a vacuum jacket which then was put into the boule press. The boule

was pressed under vacuum, and inserted into the furnace in small increments while rotating the vacuum tube at timed intervals. This is done to equalize the temperature seen by the boule. The pressed boule was then set up on a cylindrical grinder and rounded to an outside diameter of .806". Following this, the boule was hand ground and polished cn a lathe to an outside diameter of .802", without a solid rim. The boule was then placed in a precision bore tube (.802" I.D. - 1.004" O.D.) which in turn was placed in an intermediate tube (1.036" I.D. - 1.116" O.D.) which in turn was placed in a vacuum jacket (1.120" I.D. - 1.267" O.D.), all glass being G-12. This was done to achieve a rim, which when pressed again, would be large enough to yield a 1.180" O.D. after cylindrically grinding. The second press, which takes no longer than the first, was basically the same as the first press with the exception of the boule being inserted or rotated at half the normal time intervals at a lower pressing temperature.

2.1.6 Slicing, Stacking, Waxing, Rounding

After the boule was ground to 1.180" O.D., it was sliced at a 5^{o} bias. This resulted in eliptical plates which had to be ground to a uniform diameter of 1.150". In order to do this

the plates had to be waxed, stacked in a fixture, heated in a furnace, and finally ground. After grinding, the plates were reheated, separated, and dewaxed.

2.1.7 Grinding and Polishing

In the subsequent steps, the plates were ground on a planetary grinder with aluminum oxide, beveled (which prevents chipping and aids in processing), ground a second time on a planetary grinder with aluminum oxide, and then polished to final size with cerium oxide on a planetary polisher. After polishing, the plates were precleaned. They were first washed in a soapy water solution. Next, they were put through a number of chemical rinses in a teflon basket which was suspended in a beaker. The chemical rinse in the beaker was stirred magnetically. After the rinses the plates were placed in a vacuum oven to dry.

2.1.8 Final Inspection

Before sending the plates to processing, they were visually inspected under a microscope. The plates were checked for inclusions, separations of multiples, contamination, chips, scratches, improper bevel, and any other irregularities that may have occurred during fabrication. Only after passing this rigid inspection were they sent on to processing.

2.2 Wide Rim Processing

2.2.1 Chemical Processing

Etching and chemical cleaning steps were identical to those used for standard 18 mm MCPs. The plate holding fixtures for chemical processing were similar to those used for the standard 18 mm MCP.

The main change in the holding strips for wide rim plates consisted of an increased width of the strip, increased open area and recessed supporting tabs to accommodate the larger diameter of these wide rim plates. Due to these modifications only 3 plates could be held per strip. Four strips and covers were manufactured so that etching and chemical cleaning could be performed on 12 plates at a time using the present 18 mm process line.

The plate holding strips are mounted into a Teflon cover which makes it easy to transfer strips from the chemical bath to the flow rinse bath.

2.2.2 Hydrogen Firing and Vacuum Outgassing

The hydrogen firing equipment is the same as that used for standard 18 mm MCPs with the exception of the actual MCP holder. New plate holders were built, with the same basic 18 mm design, only a larger hole diameter was necessary to

accommodate the wide rim. This limited the holder capacity to only four plates per holder. A maximum of eight plates was fired simultaneously. Several activation and vacuum bake schedules were tried in order to optimize gain and conductivity while retaining the physical plate characteristics. Since the plates were thinner than regular 18 mm plates, and length to diameter ratio had to be maintained, warpage during activation is possible.

The first activation and baking schedules tried on plates 01 through 08 were within the standard 18 mm schedules. Gain and conductivity turned out to be in the acceptable range, but gain was lower than expected for this type of plate. The activation temperature on plates 09 through 14 was listed as 380°C because the end temperature of the overnight firing was the only one recorded, although the program was for 395°C. The vacuum outgassing was lowered 5°C to check for any change in the electrical characteristics over the initial set of plates processed. The next two groups of plates, from plate number 15 through 26 actual 18 mm schedules were maintained for consistency in electrical data. The next groups, plates 27 through 38, wider changes in activation temperatures were used in finding the absolute point of best gain with the least physical damage. The lower firing temperature of 390°C did not prove to be beneficial with a 395°C outgassing schedule and the 404°C firing temperature had some slight warpage effects

on plates. The 390°C firing temperature which was tried earlier was used again but the vacuum outgassing was lowered in temperature 5°C. These two groups of plates numbered 39 through 51 indicated a greater drop in gain again due to vacuum outgassing temperature still being too high for the activation temperature being used.

As part of EOPD's in-house effort, an experimental run on 25 mm plates with 10.0 micron and 12.0 micron center-to-center spacings was made to reduce warpage, which has shown that desired electrical characteristics can be achieved with reduced activation and vacuum outgassing temperatures. The same schedules were then used for wide rim plates. The H_2 activation temperature was 22°C lower and the vacuum outgassing temperature was 20°C lower. To optimize electrical characteristics for wide rim MCPs, activation temperature and time and vacuum outgassing temperature and time were altered. The plates used for these experiments are numbered 53 through 73 (see table III). The gain levels at 850 volts exceed 5,000 and the strip currents are within the required operating range of 4.5 - 5.3 microamps. This schedule was repeated for plates numbered 74 through 78 but furance problems resulted in differing characteristics.

2.2.3 Electroding

Electroding of the wide rim plates was performed in the Varian high vacuum evaporator which is also used for standard 18 mm MCPs. The only modifications needed were spacers to concentrically position the plates in the evaporation sandwich and masks to prevent overlap of inconel on the outside diameter of the MCP. Masks and spacers were manufactured to fit into present 25 mm in-house fixturing. This fixturing was adapted to the existing carousels matched to the evaporator.

With the outside diameter of fixturing being greater than that for standard plates, only 6 wide rim plates could be electroded per evaporation cycle. This cycle consisted of the deposition of inconel to a depth of 0.5 channel diameter on the input and 1.0 channel diameter inconel depth on the output side of the plate. Some 4,000 angstroms of inconel were deposited on the input side and 2,000 angstroms to the output side of the MCP resulting in a uniform surface resistance on both sides of less than 100 Ω.

2.2.4 Testing

After electroding, the plates were tested for conductivity, gain, background, emission, spots and uniformity.

Test results of all plates, along with processing schedules, are contained in Tables I, II and III. The highest gains were obtained with the highest H_2-firing temperature. Strip currents have a tendency to decrease with increasing vacuum bake temperature.

Table I. Test Results - Plates 396-01 to 396-16.

PLATE S/N	Hz Fire		Vac. Bake	1000 Volts			Thickness	Visual & Comments
	Temp. ^{o}C	Hrs.	Temp. ^{o}C 8 Hrs.	Gx1000 *	"0" Bkgd $\leq 1.0 \times 10^{-12}$ A	$I_s \times 10^{-6}$	(Mils)	
01	395	9.5	405	17.7	0	5.6	17.0	OK
02	395	9.5	405	13.1	0	6.3	17.0	OK
03	395	9.5	405	18.3	0	6.0	17.0	OK
04	395	9.5	405	12.0	0	6.2	17.0	OK
05	395	9.5	405	17.1	0	5.8	17.0	OK
06	395	9.5	405	21.4	0	6.8	17.0	OK
07	395	9.5	405	16.5	0	6.5	17.0	OK
08	395	9.5	405	NOT	ELECTRODED			CRUSHED CHANNELS
09	380	10	400	26.0	2.0×10^{-13}	9.8	17.5	POINT EMISSION CLUSTER & GRAY SPOT
10	380	10	400	29.0	0	7.5	17.5	OK
11	380	10	400	26.8	0	8.8	17.5	OK
12	380	10	400	30.2	0	8.6	17.5	OK
13	380	10	400	22.6	0	9.5	17.5	OK
14	380	10	400	-	9.0×10^{-12}	8.2	17.5	LARGE POINT EMISSION
15	395	9	396	27.0	0	6.5	17.2	OK
16	395	9	396	25.5	0	5.8	17.2	OK

Table I. Test Results - Plates 396-16 to 396-26 (continued).

PLATE S/N	H_2 Fire Temp. °C	H_2 Fire Hrs.	Vac. Bake Temp. °C 8 Hrs.	1000 Volts $G \times 1000$ *	1000 Volts "0" Bkgd $\leq 1.0 \times 10^{-12}$ A	1000 Volts $I_s \times 10^{-6}$	Thickness (Mils)	Visual & Comments
17	395	9	396	28.0	0	6.9	17.2	OK
18	395	9	396	23.0	0	6.9	17.2	OK
19	395	9	396	35.0	0	6.4	17.2	OK
20	395	9	396	26.0	0	5.8	17.2	OK
21	395	10	393	23.0	0	8.3	17.2	OK
22	395	10	393	27.0	0	7.4	17.2	OK
23	395	10	393	27.0	0	8.1	17.2	OK
24	395	10	393	25.0	0	7.9	17.2	OK
25	395	10	393	25.0	0	8.0	17.2	OK
26	395	10	393	27.0	0	8.3	17.2	OK

Table II. Test Results - Plates 396-27 to 396-42

PLATE S/N	H_2 Fire		Vac. Bake	1000 Volts			Thickness	Visual & Comments
	Temp. °C	Hrs.	Temp. °C 8 Hrs.	Gx1000 *	"0" Bkgd $\leq 1.0\times10^{-12}$ A	$I_s \times 10^{-6}$	(Mils)	
27	390	10	395	17.0	2.0×10^{-9}	9.5	17.2	3 POINT EMISSIONS & VOID
28	390	10	395	24.0	0	7.4	17.2	OK
29	390	10	395	21.0	0	7.3	17.2	OK
30	390	10	395	25.0	0	5.7	17.2	OK
* 31	390	10	395	19.0	1.0×10^{-11}	9.0	17.2	POINT EMISSION & VOID
32	390	10	395	14.0	0	6.0	17.2	2 GRAY SPOTS
33	404	10	395	28.0	0	9.6	17.2	OK SLIGHTLY WARPED
34	404	10	395	27.0	0	9.4	17.2	OK SLIGHTLY WARPED
35	404	10	395	36.0	0	8.9	17.2	OK SLIGHTLY WARPED
* 36	404	10	395	31.0	1.0×10^{-11}	7.0	17.2	POINT EMISSION SLIGHTLY WARPED
37	404	10	395	29.0	0	9.3	17.2	OK SLIGHTLY WARPED
38	404	10	395	34.0	0	9.3	17.2	OK SLIGHTLY WARPED
39	390	10	390	18.0	0	8.1	17.2	OK
40	390	10	390	15.0	0	7.5	17.2	OK
41	390	10	390	17.0	0	8.7	17.2	OK
42	390	10	390	15.0	0	8.3	17.2	GRAY SPOT

Table II. Test Results - Plates 396-43 to 396-51 (continued).

PLATE S/N	H2 Fire Temp. °C	H2 Fire Hrs.	Vac. Bake Temp. °C 8 Hrs.	1000 Volts G x1000 *	1000 Volts "0" Bkgd $<1.0\times10^{-12}$ A	1000 Volts $I_s \times 10^{-6}$	Thickness (Mils)	Visual & Comments
43	390	10	390	14.0	0	8.4	17.2	OK
44	390	10	390	22.0	0	7.4	17.2	OK
45	NON	EXISTENT	-	BROKEN	BEFORE	ETCH		
46	388	10	390	17.0	0	8.1	17.2	OK
47	388	10	390	16.5	0	7.0	17.2	OK
48	388	10	390	18.0	0	6.4	17.2	OK
49	388	10	390	17.0	0	6.2	17.2	GRAY SPOT
50	388	10	390	14.0	0	8.0	17.2	OK
51	388	10	390	15.0	0	7.8	17.2	OK
* 31	AIR BAKED		350°C	3.7	0	0.041		GRAY SPOT OXIDIZED
* 36	AIR BAKED		350°C	2.0	0	0.024		LIGHT SPOTS SURFACES

Table III. Test Results - Plates 396-53 to 396-69.

PLATE S/N	H_2 Fire		Vac. Bake	1000 Volts			Thick-ness	Visual & Comments
	Temp. ^oC	Hrs.	Temp. ^oC 8 Hrs	Gx1000 *	"0" Bkgd $< 1.0 \times 10^{-12}$ A	$I_s \times 10^{-6}$	(Mils)	
53	378	10	373	48.7	0	5.1	17.2	OK
54	378	10	373	45.0	0	4.7	17.2	OK
55	378	10	373	50.7	0	5.2	17.2	SMALL GRAY SPOT
56	378	10	373	50.7	0	5.0	17.2	OK
57	378	10	373	47.8	0	4.8	17.2	OK
58	378	10	373	56.3	0	5.0	17.2	OK
59	378	10	373	45.9	0	5.2	17.2	GRAY LINE
60	378	10	373	50.9	0	4.9	17.2	OK
61	378	10	373	56.3	0	5.1	17.2	OK
62	378	10	373	47.8	0	4.5	17.2	OK
63	378	10	373	47.8	0	4.8	17.2	OK
64	378	10	373	47.8	0	5.2	17.2	OK
65	378	10	373	47.8	0	5.6	17.2	OK
66	378	10	373	50.7	0	5.4	17.2	GRAY STREAK
67	378	10	373	53.5	0	5.2	17.2	OK
68	378	10	373	53.5	0	4.8	17.2	GRAY SPOT
69	378	10	373	56.3	0	4.7	17.2	FRACTURE (SMALL HAIRLINE)

Table III. Test Results - Plates 396-70 to 396-78 (continued).

PLATE S/N	H_2 Fire		Vac. Bake	1000 Volts			Thickness	Visual & Comments
	Temp. °C	Hrs.	Temp. °C 8 Hrs.	Gx1000 *	"0" Bkgd $\leq 1.0 \times 10^{-12}$ A	$I_s \times 10^{-6}$	(Mils)	
70	378	10	373	56.3	0	5.1	17.2	OK
71	378	10	373	54.4	0	5.1	17.2	OK
72	378	10	373	56.3	0	5.0	17.2	OK
73	378	10	373	56.3	0	5.1	17.2	OK
74	FURN.PROB. 375-380	10	375	35.2	0	11.0	17.0	OK
75	"	10	375	38.0	0	11.5	17.0	OK
76	"	10	375	39.4	0	11.0	17.0	OK
77	"	10	375	36.6	0	12.0	17.0	GRAY SPOT
78	"	10	375	38.0	0	11.0	17.0	OK

* Input Light Level 1.0×10^{-11} A/cm^2

3.0 CONCLUSIONS

Production processes required for manufacturing of wide rim 18 mm MCPs were established. Wide rim MCPs have been fabricated which meet the required physical and electrical characteristics. Wide rim MCPs can be produced with the same high yield level as attained with standard 18 mm MCPs. Increased volume production of wide rim MCPs would require the manufacture of additional fixtures and equipment.

4.0 CONFERENCES AND REPORTS

4.1 Mr. Vince Patrick visited ITT EOPD for program review conferences during the contract on the following dates:

July 12 and 13, 1976

September 9, 1976

April 6, 1977

4.2 Monthly letter progress reports and Cost and Performance reports were issued during the course of the contract.

5.0 GLOSSARY

BOULE - A solid glass cylinder containing the required number of multiple draws stacked and enclosed in a solid border glass jacket.

CHEMICAL PROCESSING - The procedure for etching the core glass from the boule slices to form the individual channels.

ELECTRODING - Depositing a metal coating across the input and output surfaces of the MCP to obtain voltage to each channel entrance and exit.

HYDROGEN FIRING - Heating the MCP slices in a hydrogen atmosphere at elevated temperatures to form the secondary emission surface on the channel walls

MULTIPLE DRAW	-	Formation of a group of single channel draws into a larger sub unit.
SINGLE DRAW	-	Formation of the two glasses which make up the channel core glass and the surrounding web.
VACUUM BAKING	-	Heating the MCP in a vacuum atmosphere to stabilize the secondary emission characteristics of the channel wall surface.
WIDE RIM	-	An extended solid diameter surrounding the active channel area of the MCP.

6.0 DISTRIBUTION LIST

		Copies
1.	NITEC 7426 Linder Avenue Skokie, Illinois 60076	1
2.	DEFENSE DOCUMENTATION CENTER 5010 Duke Street Cameron Station Alexandria, Virginia 22314	2
3.	LITTON INDUSTRIES Electron Tube Division 960 Industrial Road San Carlos, California 94070 ATTN: Arnold Davis	1
4.	AGED 201 Varick Street 9th Floor New York, New York 10014	1
5.	VARIAN LSE 611 Hansen Way Palo Alto, California 94303 ATTN: J. Edgecumbe	1
6.	VARIAN CENTRAL RESEARCH 611 Hansen Way Palo Alto, California 94303 ATTN: R. Bell	1
7.	GALILEO ELECTRO-OPTICS CORPORATION Galileo Park Sturbridge, Massachusetts 01518 ATTN: Dr. Joseph Wiza	1
8.	W26P7Z Contracting Officer's Representative Night Vision Laboratory USAECOM, DRSEL-NV-II Fort Belvoir, Virginia 22060 M/F: Contract No. DAAG53-76-C-0197	4

		Copies
9.	W26QKR MERADCOM, DRXFB-CF Fort Belvoir, Virginia 22060 M/F: Contract No. DAAG53-76-C-0197	2
10.	Defense Documentation Center ATTN: DDC-IRS 5010 Duke Street Cameron Station (Bldg. 5) Alexandria, Virginia 22314	1